COMBINING INTERNAL AND EXTERNAL INPUTS FOR SUSTAINABLE INTENSIFICATION

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Farmers and local development organizations around the world use and promote a variety of technologies to increase food production. But the high cost of inorganic fertilizers and other agrochemicals often drives farmers to rely on locally available resources instead of purchased, externally produced inputs. So-called low external input agriculture (LEIA) has spread rapidly to different parts of the globe as a challenging alternative to—or, more frequently, a complement to—Green Revolution technologies (see 2020 Vision Brief No. 55). LEIA farming typically relies on cover crops, animal manure, and improved fallow management to maintain soil organic matter content; employs conservation measures (terraces, windbreaks, hedges) to control soil erosion; and applies cultivation methods (contour farming, minimum tillage, integrated pest management [IPM]) to enhance environmental outcomes while contributing to household food security. The common element among these practices is that farmers often eschew agrochemicals and other off-farm inputs, and instead develop integrated cropping and livestock systems—including agroforestry-based systems—that permit improved nutrient cycling and biological control of pests and diseases. The goal of policy, research, and extension should be to help LEIA farmers achieve "sustainable intensification," which refers to the simultaneous increase in returns to land and labor (in the short run) and the maintenance of soil nutrient balances (in the long run).

Despite widespread efforts by governmental and nongovernmental organizations and local development projects to encourage shifts towards LEIA systems, adoption often remains limited to farmers who receive direct technical or financial support. Without such assistance LEIA practices are often readily abandoned, indicating that the underlying economic feasibility of LEIA systems is not always apparent to farmers. To improve retention rates, at least three issues must be addressed. First, instead of seeing LEIA as a universally applicable solution, its promoters should recognize that LEIA appeals primarily to small and medium-size farm households in remote regions with little access to labor markets. Second, chemical and nonchemical inputs are not mutually exclusive: labor productivity can be increased substantially when internal farm household inputs are combined with selectively applied external inputs. Third, the adoption and maintenance of these mixed internal/external input systems depend critically on supportive agrarian policies that enable farmers to invest their resources in better-integrated farming systems.

DIFFERENT FARMERS, DIFFERENT NEEDS

Farmers in Central America have a long tradition of using cover crops such as velvet bean in rotation with maize to control soil erosion and recover soil fertility. With the assistance of nongovernmental organizations (NGOs) and international development programs, cover crop systems have been widely, though unevenly, adopted. In some locations, small farm households continue to use chemical inputs because they are engaged in off-farm employment and need to reduce total farm labor requirements. Larger farms can still rely on traditional fallow and typically are less interested in more labor-intensive production systems. Farmers showing the most interest in adopting LEIA are often located in remote regions, where both product and labor markets are not highly developed.

Economic performance of low external input systems for maize production (in rotation with velvet bean) has proved to be favorable in terms of returns to land, but production systems using chemical fertilizers or traditional fallow still record substantially higher returns to labor (for one such case, see table). Consequently, small farmers engaged in the labor market are often reluctant to reduce fertilizer use, while larger farmers are able to maintain acceptable returns with a low dependence on purchased inputs and labor.

Notwithstanding these limitations, cover crops such as velvet bean have proven to be valuable complements to chemical fertilizers for family farmers deriving their income primarily from a maize-bean cropping system. In recent years, however, many farmers have abandoned the system. Velvet beans are sometimes less effective in hillside areas because of phosphorus deficits in the soil. In coastal areas, weed infestations exacerbated by erratic weather conditions have increased demands for labor and herbicides. Changes in land tenure policies have disadvantaged small farmers compared to larger farmers. Many producers have no, or only limited, access to the specialized technical support services that could help them overcome these problems. And decreasing food prices have

Performance of high and low external input and traditional maize production systems in southern Nicaragua, per annual harvest

	High input	Low input	Traditional
Maize yields (kilograms/hectare)	885	834	513
Labor use (days/hectare)	31.7	40.6	24.1
Gross returns (US$/hectare)	167	157	97
Material input costs (US$/hectare)	64	36	13
Net returns per unit of			
land (US$/hectare)	103	121	84
labor (US$/day)	3.2	3.0	3.5
capital (US$/US$)	1.6	3.4	6.2

Source: M.F.H. Bourgondien, "Low and High Input Agriculture in the Agrarian Frontier," in R. Ruben and J. Bastiaensen, eds., *Rural Development in Central America: Markets, Livelihoods and Local Governance* (New York: Macmillan, 1999).

made maize production less attractive compared to other land use alternatives, such as cattle raising.

INTERNAL AND EXTERNAL INPUTS

Programs supporting the development and diffusion of LEIA technologies are most successful when locally available inputs are combined with selectively applied external inputs. Given the lower nutrient content and the delayed nutrient availability from organically produced fertilizers (green manure, dung, compost), some use of chemical fertilizers is usually recommended. Farmers are very much aware of the fact that organic and chemical inputs are not fully substitutable.

In the Kenyan highlands, farmers have been encouraged to construct waste deposits and produce green manure to intensify vegetable production. Because decomposition is time-consuming, applications of chemical fertilizers that decrease gradually to a minimum level produce the best results. In practice, farmers hesitate to refrain completely from using purchased inputs. This reluctance is understandable because external inputs permit a better timing of land preparation, sowing, and other crop maintenance activities; reduce the demands for labor in critical periods; and produce more attractive farm products for the marketplace.

Complementarities are also found in the IPM program for plantain in Zanzibar, Tanzania. Improved nutrient applications are considered a major device for controlling pests and diseases in this program. Farmers who use small amounts of chemical fertilizers suffer far less crop loss from competition for light and nutrients or infestation. When no fertilizers are applied, diseases easily penetrate into the fields. (At the other extreme, farmers who use high doses of fertilizers risk a yield-threatening increase in the incidence of weeds.)

AGRARIAN POLICIES

Low external input technologies have been widely promoted by farmer groups and NGOs in an attempt to reduce dependencies on input suppliers and traders. Local projects have commonly provided substantial support in promoting alternative nutrient sources and covering the sunk costs of soil conservation measures. In the long run, however, genuine sustainability requires that these and related practices must be economically feasible and independent of external support. Hence, economic policies and institutional support should be in place to facilitate sustained adoption.

West African farmers could improve their cereal and cotton yields by 20 to 40 percent using locally available phosphate rock as a substitute for imported fertilizers. Transport costs are, however, typically too high to make this an affordable investment to small farmers. Limited access to credit may be another impediment. Depressed crop prices also make farmers hesitate about the use of soil phosphate amendments. Because phosphate improves nitrogen efficiency, only farmers with access to fertilizers are likely to benefit from its availability. Policies that enhance phosphate and fertilizer availability and access to credit would help sustain LEIA adoption and produce significant yield returns.

In Southern India and East Java, farmers increasingly rely on cattle dung or agroforestry as partial substitutes for chemical fertilizers. Although cereal yields are somewhat lower, the reduced input costs make returns to labor acceptable to farmers. Small farmers on rented land, however, face major problems in adopting LEIA technology. The use of alternative sources for nutrients requires that some arable land be "sacrificed" for pasture or forestry purposes, but tenants have no certainty that they will have access to this land in subsequent years. Changes in land tenure regimes to promote more secure long-term access to land would yield positive outcomes for both technology adoption and food security.

CONCLUSIONS

Finding the optimal combination of external and internal input sources is a complex process and the stakes are high. Small farmers are likely to benefit less and to abandon adoption when access to complementary external inputs is not guaranteed. On the other hand, the balanced use of organic and chemical fertilizers, herbicides, and pesticides can help farmers consistently raise land and labor productivity and maintain sustainable resource management practices.

A central constraint facing the adopters of low external input systems is economic feasibility. Returns from LEIA practices must be sufficiently attractive compared to conventional production practices and income derived from off-farm employment. Even when cost-benefit appraisals of LEIA give positive results, farmers must carefully consider the opportunity costs of farm resources. The high labor requirements of many LEIA technologies may reduce returns to labor, and family labor constraints may hinder adoption. Additional reliance on some purchased inputs may be a preferred means for maintaining farmer incomes and improving food security prospects.

Finally, adjustment of agricultural resource management regimes and farmer adoption of production practices cannot be left wholly to local initiatives. Besides training, education, and extension, policy changes and institutional support can help reinforce farmers' interest in LEIA. Well-targeted agricultural research can help reduce dependence on external inputs through work on problems such as pest resistance, drought tolerance, soil salinity, and nitrogen fixation. Stable and remunerative market prices for agricultural products are required to attract family labor to the ongoing use of yield-increasing inputs in the context of LEIA. Rural financial systems should facilitate farmers' borrowing for input purchase and insurance purposes. Farmers will require secure land tenure to enhance their willingness to invest. Concerted action in these areas is imperative to ensure that small farmers will continue to benefit from low external input technologies.

For more information, see Ruerd Ruben and Nico Heerink, "Economic Evaluation of Low External Input Farming," in the Institute for Low External Input Agriculture Newsletter, vol. 11, no. 2, 1995; and Sean Neill and David R. Lee, "Explaining the Adoption and Disadoption of Sustainable Agriculture: The Case of Cover Crops in Northern Honduras," *Economic Development and Cultural Change* (forthcoming, 2000).

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2020 VISION

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